

## 8 – ORIGINAL ARTICLE

### ALIMENTARY TRACT

# Correlation between bursting pressure and breaking strength in colonic anastomosis<sup>1</sup>

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## ABSTRACT

**PURPOSE:** To investigate the correlation between bursting pressure and breaking strength on the 7<sup>th</sup> postoperative day following left colonic anastomosis in rats.

**METHODS:** Seventy rats were randomly divided into seven groups of ten animals each. All of the animals underwent segmental resection of the left colon and end-to-end anastomosis. The animals in groups I to VI underwent surgical laparoscopies with pneumoperitoneums using carbon dioxide or helium at pressures of 5, 12 or 20 mmHg. In Group VII, open laparotomy was performed. The animals were reoperated on postoperative day 7 to measure the bursting pressure and the breaking strength of the anastomosis.

**RESULTS:** The anastomosis bursting pressure in 70 animals was 193.10±55.56 mmHg. There was no significant difference between the groups (p=0.786). The breaking strength of the anastomosis was 0.26±0.12 N. There was no significant difference between the groups (p=0.356). Pearson's correlation test showed a low correlation (r=0.231) lacking statistical significance (p=0.054).

**CONCLUSION:** There was no correlation between the bursting pressure and breaking strength of left colonic anastomoses in rats on the 7<sup>th</sup> postoperative day.

**Key words:** Anastomosis, Surgical. Colon. Tensile Strength. Pressure. Rats.

## Introduction

The ability of the human body to heal a gastrointestinal anastomosis is a fascinating event. Wound healing consists of a perfectly coordinated cascade of cellular and molecular events that interact with tissue resurfacing and reconstruction.

In colon anastomosis healing, the most feared complication is leakage, which results in devastating consequences for the patient and is associated with high rates of morbidity and mortality<sup>1</sup>. The incidence of anastomotic dehiscence in the literature ranges from 0 to 35%<sup>2</sup>. In addition, numerous factors can influence anastomosis healing, including bowel preparation, surgical technique, nutritional status, suture tension, manual or mechanical suture use, infection and the use of pharmacological agents<sup>3-5</sup>.

For the experimental evaluation of intestinal healing, mechanical, biochemical and histological parameters are used<sup>2</sup>. The two experimental mechanical parameters used to assess the anastomosis are the bursting pressure and breaking strength. Bursting pressure reflects the intestinal anastomosis resistance to an increase in intraluminal pressure, whereas the breaking strength reflects the intestinal resistance to longitudinal forces exerted towards it<sup>2</sup>.

However, the best mechanical parameter to evaluate an intestinal anastomosis, and whether there is a correlation between these two parameters, remains controversial. The objective of this study was to evaluate the correlation between the bursting pressure and breaking strength of left colonic anastomoses in rats that were subjected to various experimental stimuli.

## Methods

This study was conducted at the Laboratory of Experimental Surgery of the Faculty of Medicine, University of Brasilia (UnB). The research protocol was approved by the Ethics Committee on Animal Use at the Institute of Biological Sciences, UnB. The experimental procedures were performed according to the guidelines of the Brazilian College of Animal Experimentation.

### *Experimental design*

We used 70 male Wistar rats that were aged approximately 90 days and weighed 244-420 g. The rats were bred in Labocien – UniCEUB. These 70 rats were randomly divided into seven groups of ten animals each.

The animals were anesthetized with xylazine at a dose

of 5 mg/kg and ketamine hydrochloride at a dose of 25 mg/kg, both intramuscularly. During the operation, additional doses of anesthesia were administered as needed.

A 1-cm colon segment located between 2.5 and 3.5 cm proximal to the peritoneal reflection was resected in all of the animals. An end-to-end anastomosis running suture using 6-0 polypropylene (Brasuture® – Sao Sebastiao da Grama, Brazil) was constructed.

The animals in groups I to VI were submitted to pneumoperitoneum for 60 min prior to colonic resection and 30 min after the anastomosis with the gases and pressures listed below:

Group I – Animals submitted to CO<sub>2</sub> pneumoperitoneum at a pressure of 5 mmHg.

Group II – Animals submitted to helium pneumoperitoneum at a pressure of 5 mmHg.

Group III – Animals submitted to CO<sub>2</sub> pneumoperitoneum at a pressure of 12 mmHg.

Group IV – Animals submitted to helium pneumoperitoneum at a pressure of 12 mmHg.

Group V – Animals submitted to CO<sub>2</sub> pneumoperitoneum at a pressure of 20 mmHg.

Group VI – Animals submitted to Helium pneumoperitoneum at a pressure of 20 mmHg.

The animals in group VII (control) were subjected to laparotomy and maintained with the abdominal cavity open for 60 min prior to colonic resection and 30 min after the anastomosis.

### *Reoperation and operative analysis*

The animals were reoperated on the 7<sup>th</sup> postoperative day. After anesthesia (using the same technique as in the initial operation), a xiphopubic midline incision was performed, which provided a full view of the abdominal cavity.

### *Bursting pressure*

A ZÜRICH Z.10.RG register gauge (ZÜRICH Industria e Comercio Ltda – SP) was used to determine the anastomosis bursting pressure. With the anastomosis in situ, an incision approximately 5 cm proximal to the anastomosis was made in the colon. A urethral 10-Fr tube was introduced 1 cm intraluminally and fixed with 2-0 silk thread. Antegrade colonic lavage was performed with a 0.9% saline solution followed by careful, slow air insufflation to remove the feces. The superior rectus was carefully dissected to maintain all adhesions to the anastomosis

and was then ligated with 2-0 silk to close the intestinal lumen.

A 3-way circuit was coupled to the urethral probe, the register gauge and a compressed air cylinder. A flow of 0.5 L/min was injected into the circuit until rupture of the anastomosis. The maximum pressure was recorded at the time of the rupture (Figure 1).



**FIGURE 1** – Left colon inflated in the anatomical position with adhesions to determine the anastomosis bursting pressure.

#### *Breaking strength*

To determine the breaking strength of the anastomosis, we used a vertical test apparatus named the Versa Test® (Test Mecmesin Versa, United Kingdom), which had a traction capacity of 2,500 N, coupled to a digital portable dynamometer AGF® (Panambro Industry Technical SA – SP).

A 4-cm bowel segment, which contained the anastomosis in its central portion, was resected. The segment was then cut in half between the mesenteric border and anti-mesenteric border, and then it was subjected to the breaking strength test.

The rectangular fragment was extracted and fixed at both ends by the upper clamp of the dynamometer and the lower clamp of the Versa Test®, with the surgical scar between the clamps (Figure 2).



**FIGURE 2** – Colon segment positioned in the Versa Test® to conduct the anastomosis breaking strength test.

The traction speed for the breaking test was 25 mm/min, and the rupture value was expressed in N. The dynamometer was calibrated before each measurement series.

#### *Statistical analysis*

The SPSS 20.0® software (special package for social sciences) and Microsoft Excel® were used for the statistical analyses.

An analysis of variance (ANOVA) with Dunnett's multiple comparison analysis was used to evaluate the anastomosis bursting pressure and breaking strength.

Pearson's correlation test was used to assess the correlation between the values of anastomosis bursting pressure and breaking strength.

### **Results**

#### *Bursting pressure*

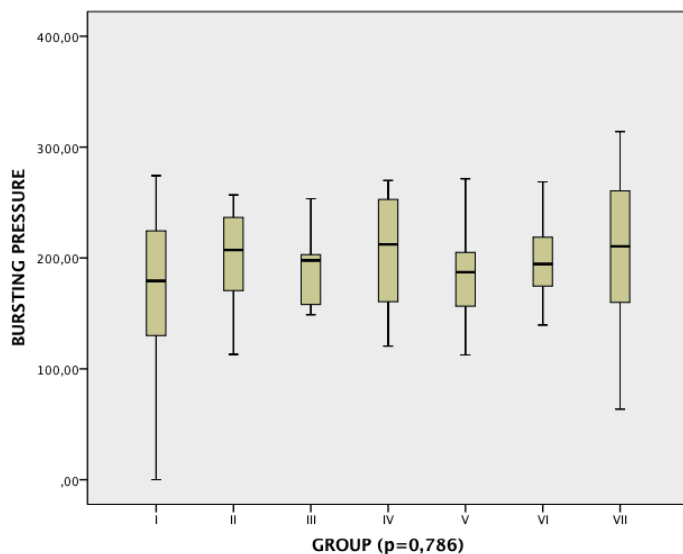
The anastomosis bursting pressure ranged from 0 to 314 mmHg in the 70 animals, with an average of 193.10 mmHg, a median of 198.25 mmHg and a standard deviation of 55.56 mmHg (Table 1)

**TABLE 1** – Bursting pressure values obtained from animals in each of the seven groups (including the mean, median, standard deviation, minimum and maximum values). Values are expressed in mmHg.

|                  | Group  |        |        |        |        |        |        |
|------------------|--------|--------|--------|--------|--------|--------|--------|
|                  | I      | II     | III    | IV     | V      | VI     | VII    |
| Mean             | 166.08 | 199.65 | 194.75 | 206.06 | 189.11 | 195.84 | 200.32 |
| Median           | 179.30 | 207.25 | 197.85 | 212.25 | 187.25 | 194.5  | 210.45 |
| Stand. Deviation | 83.30  | 46.45  | 37.49  | 49.81  | 47.39  | 36.66  | 77.22  |
| Minimum          | 0      | 113.10 | 148.80 | 120.50 | 112.60 | 139.60 | 63.70  |
| Maximum          | 274.30 | 256.90 | 253.40 | 269.90 | 271.50 | 268.60 | 314.00 |

One animal in group I had a blocked fistula and therefore presented an anastomosis bursting pressure value of 0 mmHg.

There was no significant difference between the groups ( $p=0.786$ ), and there was also no significant difference between group VII (control) and group I ( $p=0.581$ ), II ( $p=1$ ), III ( $p=1$ ), IV ( $p=1$ ), V ( $p=0.996$ ) or VI ( $p=1$ ) (Figure 3).



**FIGURE 3** – Median and interval values of the anastomosis bursting pressure in each of the seven groups, expressed in mmHg.

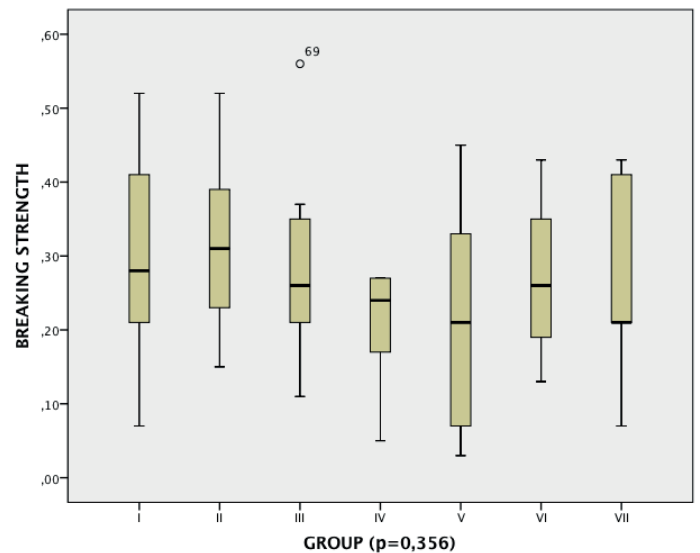
#### *Breaking strength*

The anastomosis breaking strength in the 70 animals ranged from 0.03 N to 0.56 N, with an average of 0.26 N, a median of 0.25 N and a standard deviation of 0.12 N (Table 2).

**TABLE 2** – Breaking strength values obtained for animals in each of the seven groups (including the mean, median, standard deviation, minimum and maximum values). The values are measured in N.

|                  | Group |      |      |      |      |      |      |
|------------------|-------|------|------|------|------|------|------|
|                  | I     | II   | III  | IV   | V    | VI   | VII  |
| Mean             | 0.29  | 0.31 | 0.29 | 0.20 | 0.21 | 0.27 | 0.26 |
| Median           | 0.28  | 0.31 | 0.26 | 0.24 | 0.21 | 0.26 | 0.21 |
| Stand. deviation | 0.13  | 0.12 | 0.13 | 0.08 | 0.15 | 0.10 | 0.14 |
| Minimum          | 0.07  | 0.15 | 0.11 | 0.05 | 0.03 | 0.13 | 0.07 |
| Maximum          | 0.52  | 0.52 | 0.56 | 0.27 | 0.45 | 0.43 | 0.43 |

There was no significant difference between the groups ( $p=0.356$ ), and there was also no difference between group VII (control) and group I ( $p=0.979$ ), II ( $p=0.821$ ), III ( $p=0.984$ ), IV ( $p=0.832$ ), V ( $p=0.907$ ) or VI ( $p=0.999$ ) (Figure 4).

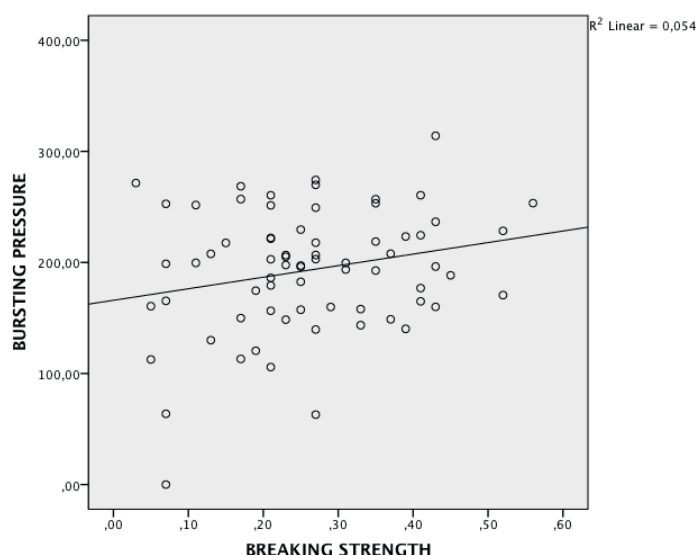


**FIGURE 4** – Median and interval values of the anastomosis breaking strength in each of the seven groups, expressed in N.

#### *Correlation between bursting pressure and breaking strength*

Using Pearson's correlation test, we observed a low correlation between the anastomosis bursting pressure and breaking strength ( $r=0.231$ ), although this correlation did not reach statistical significance ( $p=0.054$ ) (Figure 5).





**FIGURE 5** - Scatter diagram of the correlation between anastomosis breaking strength and bursting pressure.

## Discussion

Mechanical parameters are of great importance for studying intestinal anastomoses, and breaking strength and bursting pressure tests are the two most common methods used to evaluate anastomosis tensile strength. However, there is no consensus in the literature as to which method is superior. One of these two methods is used in most studies of intestinal anastomosis healing, and researchers assume that the results of both methods are strongly correlated<sup>6</sup>.

Some authors prefer to evaluate breaking strength and consider this a precise method that provides fast results<sup>7</sup>, whereas others believe that bursting pressure is more suitable for reproducing the conditions under which intestinal anastomoses will be submitted during the postoperative period<sup>2</sup>.

This investigation evaluated these two mechanical techniques to study the tensile strength of anastomoses in the left colons of rats. First, we performed the bursting pressure test with anastomoses in situ, which made it possible to maintain the intra-abdominal adhesions and their contribution to the anastomoses. Then, we performed anastomosis breaking strength tests with 50% of the circumference of the anastomosis between the mesenteric and anti-mesenteric border, in a segment that was unbroken by the bursting pressure test. In this manner, we could successfully perform both tests in the same experimental animal.

It is possible that the process of initially performing the bursting pressure test during the anastomosis could have influenced the results of the breaking strength test. However, we

did not have other options available to evaluate these two methods on the same anastomosis. All of the animals were postoperatively subjected to the same tests at the same time, which made the groups comparable.

The tissue healing process consists of three phases: 1) hemostasis and inflammation, 2) proliferation and 3) maturation. Previous studies have shown that the bursting pressure increases progressively during the 1<sup>st</sup> postoperative week, which suggests that this test would be the most appropriate for evaluating the inflammatory phase of wound healing<sup>8</sup>. At this stage, the breaking strength was shown to be constant and not to reflect the changes in the intestinal healing process<sup>8</sup>. Subsequently, the breaking strength has been shown to gradually increase after the proliferative phase<sup>9</sup>, and this phase coincides with the progressive deposition of collagen types III and I.

Our study sought to evaluate the correlation between breaking strength and bursting pressure on the 7<sup>th</sup> postoperative day, representing the interposition of the inflammatory and proliferation phases. Although we found a low correlation, which was not statistically significant, this correlation demonstrated that the results obtained with the two tests were not overlapping or unrelated, which was contrary to the original expectations.

The bursting pressure test is best suited to evaluate the integrity of the anastomosis and the risk for leaks. These leaks occur at fragile points of the anastomosis because of either small areas of local necrosis or failures related to the surgical technique. This test is also the most appropriate for the inflammatory healing phase<sup>6</sup>. In contrast, the breaking strength test better reflects the anastomosis as a whole and is more useful in the proliferative and maturation phases<sup>2</sup>.

## Conclusion

There was no correlation between the bursting pressure and breaking strength of left colonic anastomoses in rats on the 7<sup>th</sup> postoperative day.

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